Report on "Physics with Tagged Forward Protons with the STAR Detector at RHIC" by H. Spinka et al.

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Introduction

This is a proposal to study elastic pp scattering and inelastic pp diffraction in STAR. The inelastic pp diffraction includes a search for gluon-rich mesons produced in double-Pomeron interactions. The search for gluon-rich exotica (like glueballs) would make use of the 'p_T filter' developed at the CERN SPS, but making use of the 10 times higher RHIC energy. .

The proposal has two phases. Phase I involves moving the Roman pots from the pp2pp experiment to the STAR interaction region, and duplicating the beam optics used for pp2pp. The Roman pots will go between the Q3 and Q4 quadrupoles, 50-60 meters downstream from the interaction point. The cost for Phase I is about $60K. Phase I requires 3 days of data in 2005/6, with special beam optics (beta* = 20 meters, leading to a luminosity estimated at 2*10^{29}/cm^2/s).

The proponents are also interested in a second 3-day run (presumably in 2006/7), to study elastic scattering with both longitudinal and transverse polarization. This is not discussed in the current proposal, but seems like a reasonably straightforward extrapolation of the current running.

Phase II involves moving these Roman pots to different locations, probably between the DX and D0 magnets, or building and installing additional pots. The costs for this are not estimated, but they are considerably larger than Phase I. There is also the potential for a space conflict with the shielding that STAR is about to install. If this becomes a real conflict, we judge that it can be fairly easily worked out.

The Phase II configuration has not yet been detailed. Between the unknown acceptance and the unknown costs, we cannot evaluate the cost:benefit ratios. There do not appear to be any show-stoppers.

Scientific Merit:

The physics potential for Tagged Forward Protons with STAR is high. This physics is not always brought out clearly in the proposal, but is discussed in the literature.

Phase I will study polarized and unpolarized (spin averaged) pp elastic scattering down to low t-values. It will also allow for comparisons of pp and pbar-p (from the Tevatron) scattering - at high energies, the cross sections are expected to be the same. A difference could be due to the Odderon, the hypothesized 3-gluon analog of the 2-gluon Pomeron. Finally, it will allow for a 5% measurement of σ_{tot}, along with a measurement of the ratio

of the real to imaginary cross sections, ρ, to 0.01 and the slope parameter Δb (related to the size of the proton) to 0.31 $(GeV/c)^{-2}$.

Phase I will also study central diffraction interactions (CDI), pp going to ppX, where X is at mid-rapidity, surrounded on both sides by rapidity gaps. The decay products from X are detected in the TPC, and the scattered protons in the Roman pots, allowing for full reconstruction of the events. CDI interactions proved to be an extremely fruitful venue for meson spectroscopy studies at the CERN SPS. There, the WA76/91/102 series of experiments discovered the 'p_T filter" phenomenon whereby meson p_T appears to be an effective selector for differentiating standard quark-antiquark mesons from less conventional objects.

In 3 days of running, an estimated 200,000 central diffractive interactions (CDI) can be collected. This is comparable or better statistics to that collected by the WA76/82/91/102 experiments at the CERN SPS. STAR will add several new dimensions to this data:

a) With the higher beam energy at RHIC, CDI are almost purely double-Pomeron, while at the SPS, significant meson exchange may have been present. The higher energy also widens the rapidity gaps (giving better separation between the protons and the central state), and hence smaller backgrounds. Since, with Roman pots, STAR will reconstruct the entire event, the lack of intermediate-rapidity instrumentation is not a problem. The higher beam energies will also allow STAR to study higher-mass final states. .

b) With polarized protons, STAR can study the spin dependence of CDI interactions, and thus shed light on the spin of the Pomeron. It is worth mentioning that Dima Kharzeev has written papers claiming that the Pomeron is spin 1, in contrast to the usual spin-0 expectation.

Phase I has a more limited p_T acceptance (roughly $p_T<150$ MeV/c for each proton) than the SPS experiments. This may limit the applicability of the 'p_T filter' in the Phase I data; the low p_T data probed in phase I is the exotic-rich region, but Phase I will have limited access to the higher p_T at which conventional mesons are produced more copiously; this higher p_T region is useful as a 'standard.'

Overall, the proposal offers a solid study of pp elastic scattering, and an exciting opportunity to look at inelastic diffraction at energies 10 times higher than were studied at the SPS, and with the advantages of polarized beams. We feel that this is a very solid physics program, especially considering the limited costs.

Technology Choice and Technical Feasibility

The technology involved in the proposal is mature. The proposal includes relevant experts, so we see no significant show-stoppers or items requiring R & D.

No details are given on the combined Roman Pot/STAR algorithms used to study inelastic diffraction. This will require some study and perhaps algorithm development to ensure that the rates are kept within the STAR DAQ limits.

The special beta*=20 meters optics will require some beam development. The proposal allocates 12 hours for beam development, in accord with previous pp2pp experience. This is somewhat less than the CAD estimate of ~ 1 day, but this difference does not seem that significant. During the running, the PHENIX luminosity may be somewhat reduced, due to the need for increased beam scraping.

Technical Specifications

The pp2pp technology is optimum for studying elastic scattering. It is clearly adequate for studying double-Pomeron (DPE) interactions, although higher proton p_T acceptance would be helpful. It may be that a detector with 2π azimuthal coverage would be better for studying DPE interactions.

Detector Integration

Although few details are given, trigger and DAQ integration has been discussed with the relevant experts (for DAQ, the relevant experts are on the proposal), and integration should be quite straightforward.

The beam optics are identical to those for pp2pp, and should be well understood. Coordination with the RHIC vacuum group is required for Roman pot installation.

The issue of integrating these two groups (publication policy, shifts, etc.) should be discussed by STAR management and the proponents at an appropriate time.

Resources, Cost and Schedule

Most of the costs consist of labor, plus some additional mechanical components. The budget is very modest, and any overruns are likely to be controllable.

The group appears to have adequate manpower. The STAR UPC group is very enthusiastic about this proposal, and many UPCers are interested in getting involved. This will be very helpful in getting the group integrated into STAR, as well as turning the new (to STAR) hardware into physics results

No detailed schedule was given. The major schedule driver is likely to be physical installation of the Roman pots, something that is the purview of the RHIC vacuum group. If given adequate priority, there should be time to install the Roman pots before the next run begins. It is worth noting that the group has already begun to remove the Roman pots from the pp2pp IR, in preparation for the move.

Conclusions

Phase I of this proposal promises a good amount of physics for a very small cost; the largest cost is the 3 days of dedicated running. We recommend that the collaboration endorse the proposal (subject to the understanding that a further proposal is required for Phase II).